Study Report

Environmental test

of

ECOMARINE Ballast Water Treatment System

January 31, 2012

National Maritime Research Institute.

STATEMENT

Title of study: Environmental test of the ECOMARINE ballast water treatment system

Study number: T-01-200

The Environmental test of the ECOMARINE ballast water treatment system was conducted by the National Maritime Research Institute. based on the standards for the type approval evaluation test of ballast water treatment systems (established by the Inspection and Measurement Division of the Maritime Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, Japan), and the study protocol.

Responsible personnel (study director)
National Maritime Research Institute.

(Signature) Kenji Yamane (Kenji Yamane)
(Date) January 31, 2012

QUALITY ASUURANCE STATEMENT

Title of study:Environmental test of the ECOMARINE ballast water treatment system

Study number: T-01-200

The Environmental test of the ECOMARINE ballast water treatment system was conducted by the National Maritime Research Institute. according to the below schedule and the inspection result was reported to the study director.

Date of inspection	Type of inspection / Study phase inspected	Date of report
Aug. 26, 2011	Study-based inspection / Study protocol	Sep. 1, 2011
Oct. 18, 2011	Facility-based inspection / SOPs	Oct. 20, 2011
Nov. 4 and Nov. 22, 2011	Study-based inspection / Experimental phase	Nov. 24, 2011
Nov. 28, 2012	Study report (draft)	Nov. 30, 2012
Jan. 26, 2012	Study report (final)	Jan. 31, 2012

It is guaranteed the environmental test was conducted in accordance with the study protocol and the inspection result was accurately reflected in the description provided in this report.

Responsible personnel (quality assurance management)
National Maritime Research Institute.

(Signature) Kenji Yamane (Kenji Yamane)

(Date) January 31, 2012

Contents

1. Summary of test

The environmental test of the ECOMARINE ballast water treatment syste (treatment capacity: 200 m^3/h) is conducted to evaluate the environmental impact of the UV unit (type: SIEMENS BarrierM 3800) and the filter unit motor (type: Sumitomo Heavy Industries RNYM3-1510-5) in accordance with the standards for environmental test of ballast water treatment systems established by the Inspection and Measurement Division of the Maritime Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, Japan .

2. Test equipment

2.1 UV unit

Manufacturer	: Sumitomo Electric Industries, Ltd.
Type	: UV200
Specifications	
< control panel and UV chamber >	
Power supply	: three-phase (60 Hz) 440V (three-phase 220V applicable)
Ambient temperature	: 0 to 55 ^{o}C
Water pressure	: 0 to 1 MPa
Water quality	: Seawater, brackish water
Water temperature	: 0 to 55 ^{o}C
< UV lamp: medium-pressure, 3.5 kW per lamp >	
Quantity	: 6 in the UV chamber
Intensity measurement point	: 3 in the UV chamber
Effective intensity	: not less than115 W/m^2

2.2 Filter unit motor

Manufacturer	: Sumitomo Heavy Industries, Ltd.
Type	: RNYM3-1510-5
Specifications	
Power supply	: three-phase 440V
Rated output	: 2.2 kW
Storage temperature	: -40 to 60 ^{o}C
Operational temperature	: -10 to 50 ^{o}C
Operational humidity	: 50 to 90 % RH

3. Test condition

A series of environment test (vibration test, temperature test, humidity test, power fluctuation test, inclination test) is conducted in the environment test facility of National Maritime Research Institute.

3.1 Vibration test

3.1.1 Apparatus used for test

Manufacturer : IMV Corporation
Type : TBH-10-CE05-A
Specifications
Vibration table dimension : 1000mm x 1000mm x 30mm
Vibration table weight : 100kg
Output : 1000kgf
Maximum acceleration : 66G

3.1.2 Study protocol and operation confirmation method

Title	Test specification	Criterion	Procedure	Evaluation method
Resonance vibration test 1	1. 2 to 13.2 Hz with a vibration amplitude of ±1 mm 2. 13.2 to 80 Hz with an acceleration amplitude of 0.7 g The BWTS is vibrated three times in each of the three orthogonal planes for a period of 1.5 hours, with a sweeping time of 10 minutes.	There should be no abnormality such as damage, deformation and malfunction.	① UV unit control panel Fix a specimen to the BWTS base. Supply power in the test facility into the UV unit. Install input/output cables from the control panel to the UV chamber. Display specific data on the control panel. Record the data displayed on the control panel after the load of vibration. ② UV chamber Fix a specimen to the BWTS base. Supply water in the test facility into the UV chamber. Install input/output cables from the UV chamber to the control panel. Display specific data on the control panel. Record the data displayed on the control panel after the load of vibration. ③ filter unit motor Fix a specimen to the BWTS base. Supply power in the test facility into the filter unit. Check the motor rotation after the load of vibration.	① and ② • Visually check any damage and deformation. • Check the data displayed on the control panel. If the data does not change significantly, it means that there is no abnormality. • As a minimum requirement, the UV irradiance detected by the three UV sensors should not be less than 115 W/m^2. • ③ The motor should continue to rotate properly without any interruption.
Vibration resistance test	In the presence of any resonance point in the resonance vibration test 1, the BWTS is vibrated one time in each of the three orthogonal planes at the vibration amplitude with the acceleration amplitude in the resonance vibration test 1 for a period of 6 hours. In the absence of any resonance point in the resonance vibration test 1, the BWTS is vibrated one time in each of the three orthogonal planes at 30 Hz with an acceleration amplitude of 0.7 g for a period of 6 hours.	There should be no abnormality such as damage, deformation and malfunction.		
Resonance vibration test 2	1. 2 to 13.2 Hz with a vibration amplitude of ±1 mm 2. 13.2 to 80 Hz with an acceleration amplitude of 0.7 g The BWTS is vibrated one time in each of the three orthogonal planes for a period of 0.5 hours, with a sweeping time of 10 minutes.	There should be no abnormality such as damage, deformation and malfunction. There should be no significant change in vibration property.		

3.2 Temperature and humidity tests

3.2.1 Equipment used for test

Manufacturer : SANYO Co., Ltd.
Description : prefab constant temperature room
Specifications
Dimension : 3600mm×4500mm×4800mm
Temperature : -10 to 60°C
Humidity : 60 to 98%

3.2.2 Study protocol and operation confirmation method

Title	Test specification	Criterion	Procedure	Evaluation method
Temperature test	Leave the equipment at 0 °C and at 55 °C for a period of not less than two hours. Then, supply power and confirm the operation.	There should be no abnormality such as damage, deformation and malfunction.	① UV unit control panel Set a specimen in the constant temperature room. Supply power in the test facility into the UV unit. Install input/output cables from the control panel to the UV chamber. Display specific data on the control panel. Record the data displayed on the control panel after the load of temperature and humidity. ② UV chamber Set a specimen in the constant temperature room. Supply water in the test facility into the UV chamber. Install input/output cables from the UV chamber to the control panel. Display specific data on the control panel. Record the data displayed on the control panel after the load of temperature and humidity. ③ Filter unit motor Set a specimen in the constant temperature room. Supply power in the test facility into the filter unit. Check the motor rotation after the load of temperature and humidity.	① and ② • Visually check any damage and deformation. • Check the data displayed on the control panel. If the data does not change significantly, it means that there is no abnormality. • As a minimum requirement, the UV irradiance detected by the three UV sensors should not be less than 115 W/m^2. ③ The motor should continue to rotate properly without any interruption.
Humidity test	Leave the equipment at 55 °C and at 90 % relative humidity for a period of two hours. Then, supply power and confirm the operation.	There should be no abnormality such as damage, deformation and malfunction.		

3.3 Power fluctuation test

3.3.1 Equipment used for test

Manufacturer : NIPPON SHARYO, Ltd.
Description : diesel engine generator
Type : S/S 125/100KVA
Specifications
Output power : 100KW
Output voltage : three phase 440V±20% (variable)
Output frequency : 60Hz±10% (variable)

3.3.2 Study protocol and operation confirmation method

Title	Test specification	Criterion	Procedure	Evaluation method
Continuous voltage/frequency fluctuation test	A voltage variation of ± 10 % together with a simultaneous frequency variation of ±5 %	There should be no abnormality such as damage, deformation and malfunction.	① UV unit control panel Set a specimen in the constant temperature room. Supply power in the test facility into the UV unit. Install input/output cables from the control panel to the UV chamber. Display specific data on the control panel. Record the data displayed on the control panel after the load of power fluctuation. ② UV chamber Set a specimen in the constant temperature room. Supply water in the test facility into the UV chamber. Install input/output cables from the UV chamber to the control panel. Display specific data on the control panel. Record the data displayed on the control panel after the load of power fluctuation. ③ Filter unit motor Set a specimen in the constant temperature room. Supply power in the test facility into the filter unit. Check the motor rotation after the load of power fluctuation.	① and ② • Visually check any damage and deformation. • Check the data displayed on the control panel. If the data does not change significantly, it means that there is no abnormality. • As a minimum requirement, the UV irradiance detected by the three UV sensors should not be less than 115 W/m^2. ③ The motor should continue to rotate properly without any interruption.
Instantaneous voltage/frequency fluctuation test	A transient voltage of ± 20 % together with a simultaneous frequency variation of ±10 %, with a transit recovery time of three seconds	There should be no abnormality such as damage, deformation and malfunction.		

3.4 Inclination test

3.4.1 Equipment used for test

Description : 1 ton hoist type overhead crane, 500 kg electric forklift truck and two 300 kg manual forklift trucks

3.4.2 Study protocol and operation confirmation method

Title	Test specification	Criterion	Procedure	Evaluation method
Instantaneous voltage/frequency fluctuation test	A transient voltage of ± 20 % together with a simultaneous frequency variation of ±10 %, with a transit recovery time of three seconds	There should be no abnormality such as damage, deformation and malfunction.	① UV unit control panel Set a specimen in the constant temperature room. Supply power in the test facility into the UV unit. Install input/output cables from the control panel to the UV chamber. Display specific data on the control panel. Record the data displayed on the control panel after the load of inclination. ② UV chamber Set a specimen in the constant temperature room. Supply water in the test facility into the UV chamber. Install input/output cables from the UV chamber to the control panel. Display specific data on the control panel. Record the data displayed on the control panel after the load of inclination. ③ Filter unit motor Set a specimen in the constant temperature room. Supply power in the test facility into the filter unit. Check the motor rotation after the load of inclination.	① and ② • Visually check any damage and deformation. • Check the data displayed on the control panel. If the data does not change significantly, it means that there is no abnormality. • As a minimum requirement, the UV irradiance detected by the three UV sensors should not be less than 115 W/m^2. ③ The motor should continue to rotate properly without any interruption.

4.Conclusion

4.1 Tests efficacy

The test equipment was managed property in this test. The Environmental test was conducted based on the standards for the type approval evaluation test of ballast water treatment systems (established by the Inspection and Measurement Division of the Maritime Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, Japan) and the rational result was provided.
According, it is determined that this test is valid.

4.2 Vibration test

4.2.1 UV unit

It is determined that there is no effect of vibration on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the vibration test.
The tests results show in appendix 1, the study report of Environmental test.

4.2.2 Filter unit motor

It is determined that there is no effect of vibration on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the vibration test.
The tests results show in appendix 1, the study report of Environmental test.

4.3 Temperature and Humidity test

4.3.1 UV unit

It is determined that there is no effect of temperature and humidity on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the temperature and humidity test.
The tests results show in appendix 1, the study report of Environmental test.

4.3.2 Filter unit motor

It is determined that there is no effect of temperature and humidity on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the temperature and humidity test.
The tests results show in appendix 1, the study report of Environmental test.

4.4 Power fluctuation test

4.4.1 UV unit

It is determined that there is no effect of power fluctuation test on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the power fluctuation test.

The tests results show in appendix 1, the study report of Environmental test.

4.4.2 Filter unit motor

It is determined that there is no effect of power fluctuation test on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the power fluctuation test.

The tests results show in appendix 1, the study report of Environmental test.

4.5 Inclination test

4.5.1 UV unit

It is determined that there is no effect of inclination test on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the inclination test.

The tests results show in appendix 1, the study report of Environmental test.

4.5.2 Filter unit motor

It is determined that there is no effect of inclination test on the equipment because there was no abnormality in the equipment such as damage, transformation or malfunction throughout the inclination test.

The tests results show in appendix 1, the study report of Environmental test.

Study Report Environmental test of ECOMARINE Ballast Water Treatment System

APPENDIX

January 31, 2012

National Maritime Research Institute

Independent administarative corporation

Purpose

1． Vibration tests

methods	1) ±1m amplitude of vibration &0.7G sweep tests （（10minutes＋10minutes）x3times） 2) Vibration resistance tests of resonance point（2hour） 3)±1m amplitude of vibration tests &0.7Gsweep tests （（10minutes＋10minutes）x1times）

1． 1 Control panel

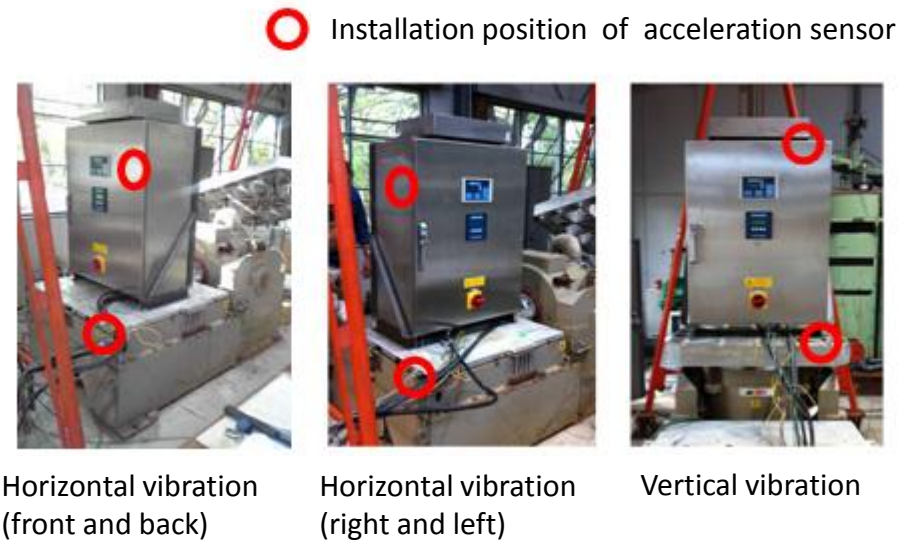


Fig1.1 vibration stage and

Installation placement of acceleration sensor

1． 1． 1 X direction（Apparatus original center of the forehead or left and right）vibration

condition0 Before the beginning of the test

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	143	134	127	30	27
121.1	143	134	127	30	27
121.1	143	134	127	30	27

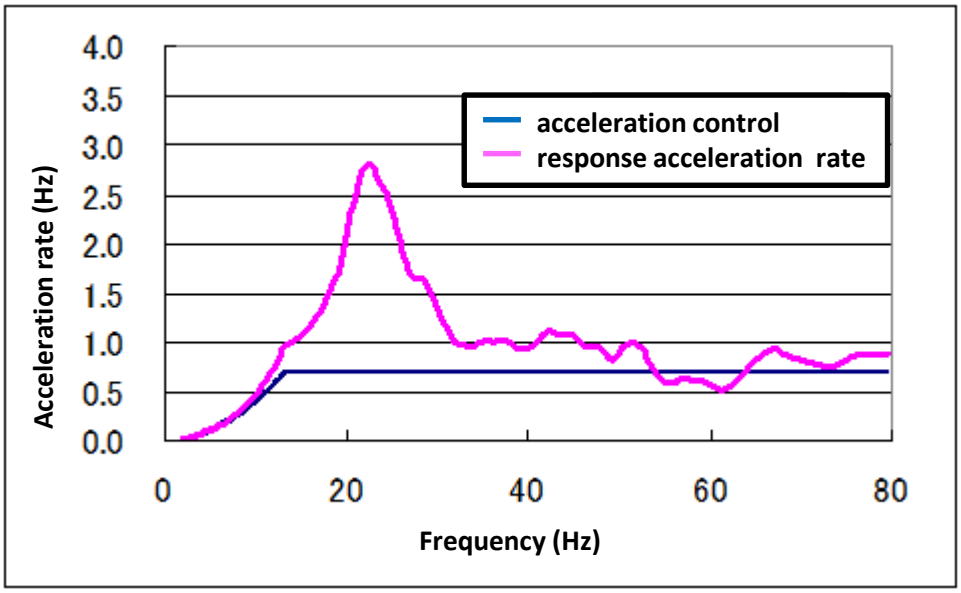


Fig1.2 response acceleration rate before earthquake resistant tests

（three test cycles）

condition1 Test cycle1: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	143	134	127	30	27
121.1	143	134	127	30	27
121.1	143	134	127	30	27

condition2 Test cycle1: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	143	141	128	29	27
121.1	143	140	128	29	27
121.1	143	140	128	29	27

condition3 Test cycle2: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.0	153	141	128	29	27
121.0	154	140	129	29	27
121.0	152	140	129	29	27

condition4 Test cycle2: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	154	144	131	29	27
125.0	155	144	130	29	27
125.0	154	144	130	29	27

condition5 Test cycle3: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	153	146	130	30	27
125.0	153	146	130	30	27
125.0	154	146	131	30	27

condition6 Test cycle3: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	155	148	131	30	27
125.0	157	148	131	30	27
125.0	156	148	130	30	27

condition7 Just after the beginning of the test 2)

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	155	148	131	30	27
125.0	157	148	131	30	27
125.0	156	148	130	30	27

condition8 The beginning of the test 2)1hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	157	137	131	29	27
125.0	157	137	131	29	27
125.0	157	137	131	29	27

condition9 The beginning of the test 2) 2hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	158	142	130	29	27
125.0	158	142	130	29	27
125.0	158	142	130	29	27

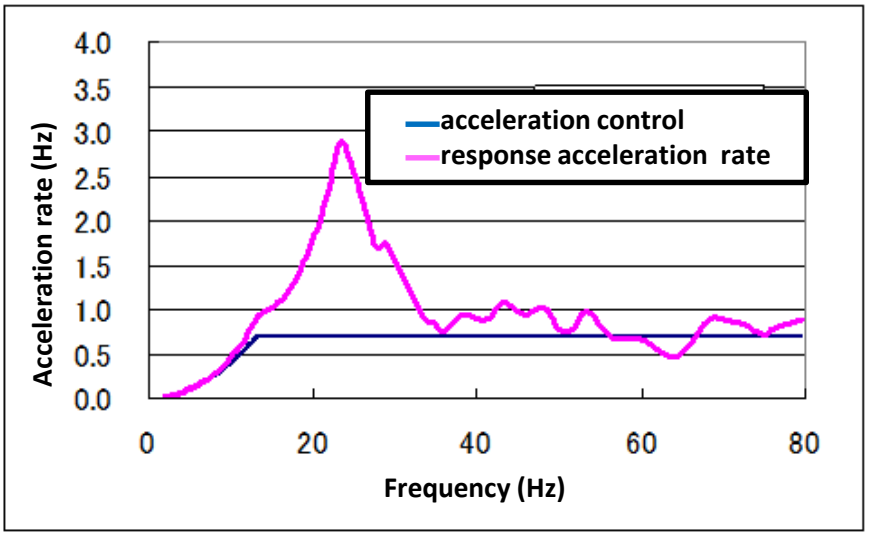


Fig1.3 response acceleration rate after earthquake resistant tests

condition10 Test 3)、around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	158	142	130	29	27
125.0	158	142	130	29	27
125.0	158	142	130	29	27

condition11 Test 3)、around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	158	142	130	29	27
125.0	158	142	131	29	27
125.0	158	142	131	29	27

１．１．２ Y direction（Apparatus original center of the forehead or front and back）Vibration

condition0 Before the beginning of the test

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.0	142	133	126	30	26
121.0	142	133	126	30	26
121.0	142	133	126	30	26

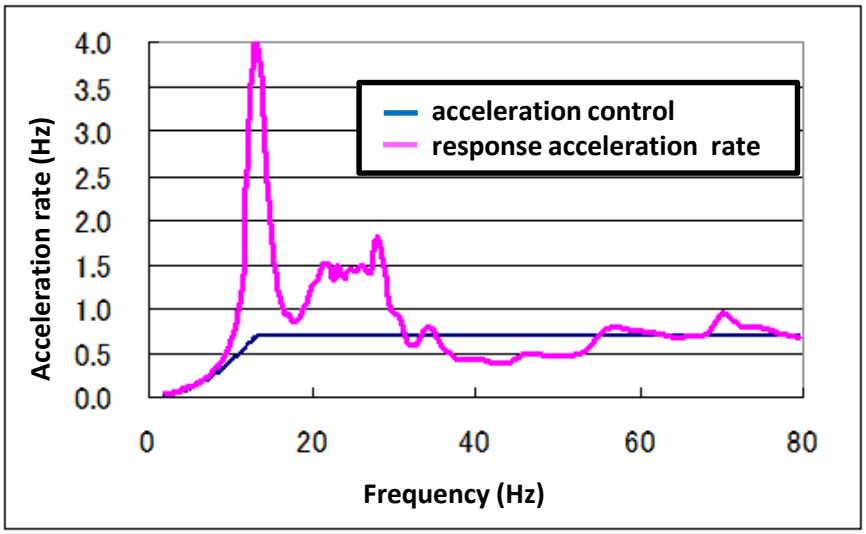


Fig1.4 response acceleration rate before earthquake resistant tests

（three test cycles）

condition1 Test cycle1: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.0	142	133	126	30	26
121.0	142	133	126	30	26
121.0	142	133	126	30	26

condition2 Test cycle1: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	145	132	131	30	26
125.0	145	132	131	30	26
125.0	145	132	131	30	26

condition3 Test cycle2: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	142	131	131	30	26
125.0	142	131	131	30	26
125.0	142	131	131	30	26

condition4 Test cycle2: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	142	131	131	30	26
125.0	142	131	131	30	26
125.0	142	131	131	30	26

condition5 Test cycle3: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	145	132	131	30	26
125.0	144	132	132	30	26
125.0	144	132	132	30	26

condition6 Test cycle3: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	150	134	131	30	26
125.0	150	134	131	30	26
125.0	150	134	131	30	26

condition7 Just after the beginning of the test 2)

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	150	136	131	29	26
125.0	153	136	131	29	26
125.0	149	137	131	29	26

condition8 The beginning of the test 2) 1hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	142	132	131	30	25
125.0	144	132	131	30	25
125.0	142	132	131	30	25

condition9 The beginning of the test 2) 2hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	147	143	131	29	26
125.0	144	143	131	29	26
125.0	147	144	131	29	26

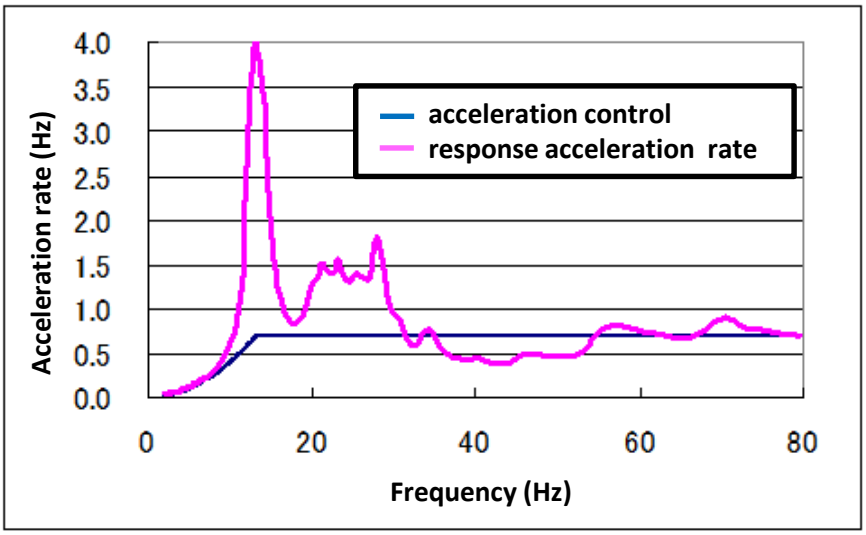


Fig1.5 response acceleration rate after earthquake resistant tests

condition10 Test 3)、around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	149	144	131	29	26
125.0	145	143	131	29	26
125.0	145	144	131	29	26

condition11 Test 3)、around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	144	144	131	29	26
125.0	144	144	131	29	26
125.0	144	145	131	29	26

１．１．３ Z direction（Apparatus original center of the forehead or up and down） vibration

condition0 Before the beginning of the test

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	150	140	130	30	26
125.0	147	138	130	30	26
125.0	146	137	130	30	26

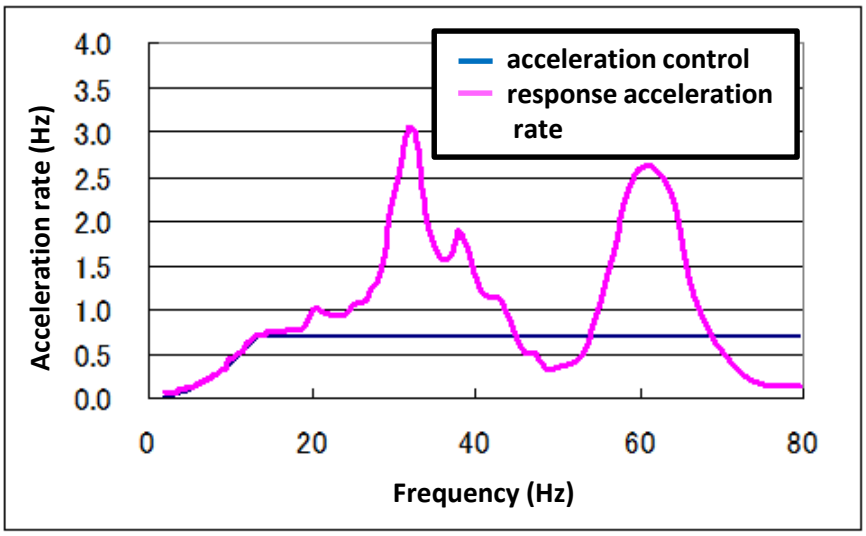


Fig1.6 response acceleration rate before earthquake resistant tests

（three test cycles）

condition1 Test cycle1: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	150	140	130	30	26
125.0	147	138	130	30	26
125.0	146	137	130	30	26

condition2 Test cycle1: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	146	135	129	30	26
125.0	146	135	130	30	26
125.0	145	134	129	30	26

condition3 Test cycle2: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	147	134	130	30	26
125.0	148	134	129	30	26
125.0	147	133	129	30	26

condition4 Test cycle2: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	145	133	130	29	26
125.0	143	132	130	29	26
125.0	145	133	130	29	26

condition5 Test cycle3: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	145	133	130	29	26
125.0	147	133	129	29	26
125.0	144	133	130	29	26

condition6 Test cycle3: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	142	133	129	29	26
125.0	142	133	129	29	26
125.0	144	133	129	29	26

condition7 Just after the beginning of the test 2) (32.8Hz)

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	142	133	129	29	26
121.1	143	133	129	29	26
121.1	144	133	129	29	26

condition8 The beginning of the test 2) 1hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	147	138	128	29	26
121.1	145	138	128	29	26
121.1	145	138	128	29	26

condition9 The beginning of the test 2) 2hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	147	143	129	29	26
121.1	149	143	128	29	26
121.1	147	142	128	29	26

condition10 Just after the beginning of the test 2) (60.8Hz)

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	149	136	128	29	26
121.1	148	135	128	29	26
121.1	147	135	128	29	26

condition11 The beginning of the test 2) 1hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	147	136	128	29	26
121.1	148	137	128	29	26
121.1	147	137	129	29	26

condition12 The beginning of the test 2) 2hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	147	144	128	29	26
121.1	147	144	128	29	26
121.1	146	144	128	29	26

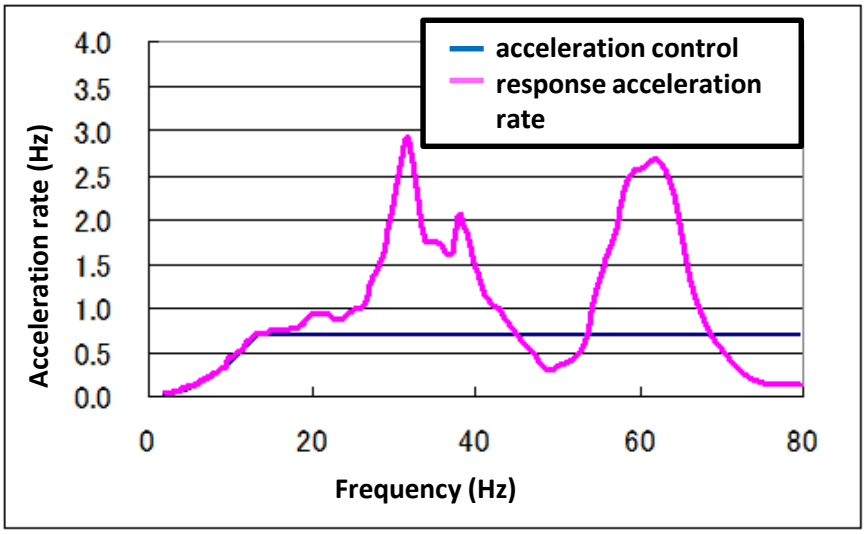


Fig1.7 response acceleration after earthquake resistant tests

condition13 Test 3)、around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	148	132	128	29	26
121.1	147	132	128	29	26
121.1	148	132	128	29	26

condition14 Test 3)、around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	149	132	128	29	26
121.1	147	132	128	29	26
121.1	149	132	128	29	26

1 . 2 UV chamber

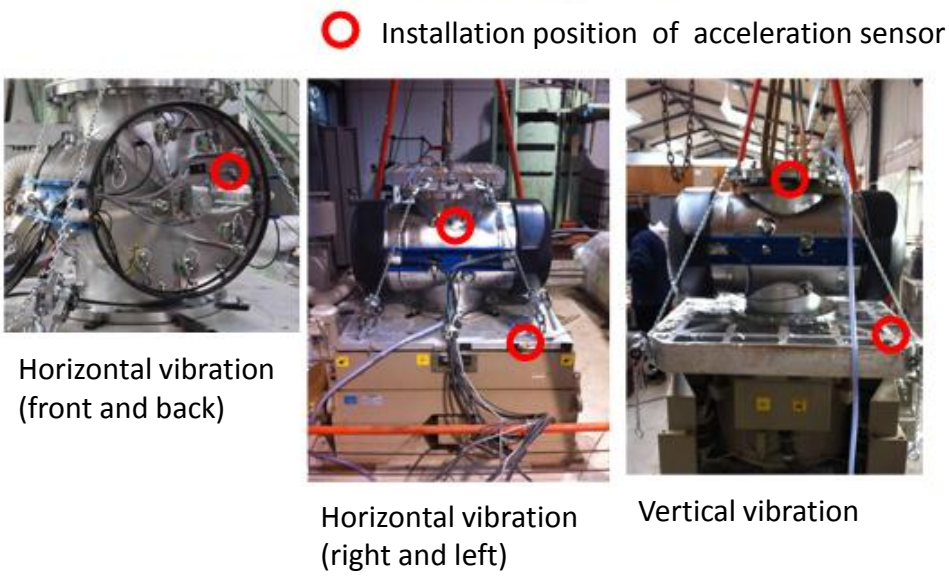


Fig1.8 vibration stage and Installation placement of acceleration sensor

1．2．1 X direction (Apparatus original center of the forehead or left and right) vibration

condition0 Before the beginning of the test

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
119.9	154	134	128	27	27
119.9	155	134	128	27	27
119.9	157	134	128	27	27

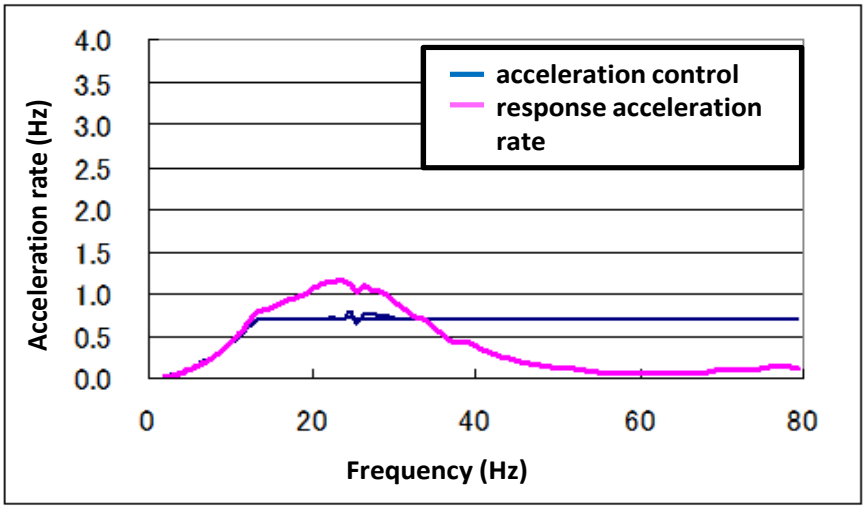


Fig1.9 response acceleration rate before earthquake resistant tests (three test cycles)

condition1 Test cycle1: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
119.9	156	134	128	27	27
119.9	157	134	128	27	27
119.9	157	134	128	27	27

condition2 Test cycle1: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
119.9	153	133	128	27	27
119.9	153	133	128	27	27
119.9	153	133	128	27	27

condition3 Test cycle2: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	157	134	128	27	27
119.9	157	134	128	27	27
119.9	157	134	128	27	27

condition4 Test cycle2: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	159	136	128	27	27
121.1	159	136	128	27	27
121.1	159	136	128	27	27

condition5 Test cycle3: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	161	137	130	27	27
125.0	160	137	129	27	27
125.0	161	137	129	27	27

condition6 Test cycle3: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	160	144	130	27	27
125.0	159	144	130	27	27
125.0	160	144	130	27	27

condition7 Just after the beginning of the test 2) (25Hz)

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	157	145	130	27	27
125.0	158	145	130	27	27
125.0	157	145	130	27	27

condition8 The beginning of the test 2) 1hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	158	140	131	26	27
125.0	157	141	131	26	27
125.0	158	140	131	26	27

condition9 The beginning of the test 2) 2hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	155	137	132	26	27
125.0	154	137	132	26	27
125.0	154	137	132	26	27

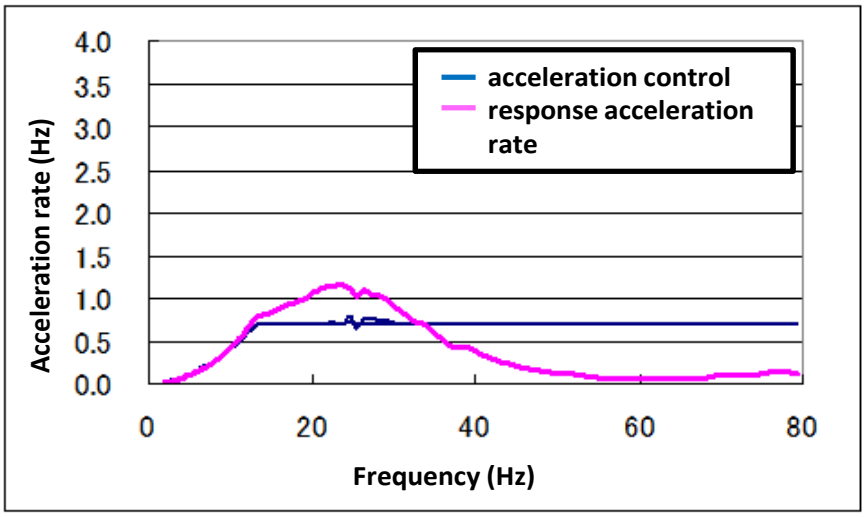


Fig1.10 response acceleration rate after earthquake resistant tests

condition10 Test 3)、around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	156	145	132	26	27
125.0	155	145	133	26	27
125.0	155	146	132	26	27

condition11 Test 3)、around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	153	146	132	26	27
125.0	154	145	132	26	27
125.0	154	146	132	26	27

１．２．２ Y direction（Apparatus original center of the forehead or front and back）vibration

condition0 Before the beginning of the test

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	158	143	130	27	26
125.0	158	143	130	27	26
125.0	158	143	130	27	26

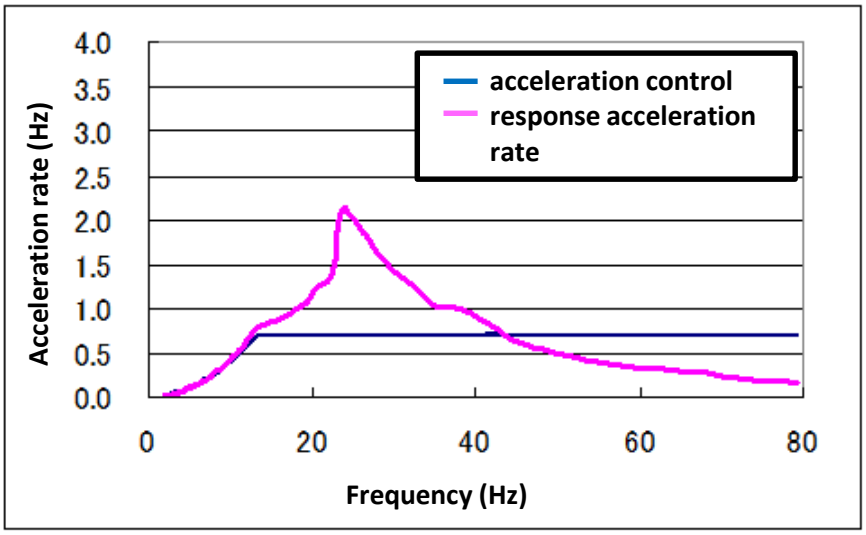


Fig1.11 response acceleration rate before earthquake resistant tests (three test cycles)

condition1 Test cycle1: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	153	143	129	27	26
125.0	153	143	129	27	26
125.0	153	143	129	27	26

condition2 Test cycle1: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	158	143	129	27	26
125.0	158	143	129	27	26
125.0	158	143	129	27	26

condition3 Test cycle2: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	157	142	129	27	26
125.0	157	142	129	27	26
125.0	157	142	129	27	26

condition4 Test cycle2: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	153	140	129	27	26
125.0	153	140	129	27	26
125.0	153	140	129	27	26

condition5 Test cycle3: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	156	142	129	27	26
121.1	156	142	129	27	26
121.1	156	142	129	27	26

condition6 Test cycle3: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	154	142	123	27	26
121.1	154	142	123	27	26
121.1	154	142	123	27	26

condition7 Just after the beginning of the test 2) (25Hz)

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	154	141	129	27	26
121.1	154	141	129	27	26
121.1	154	141	129	27	26

condition8 The beginning of the test 2) 1hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	151	129	128	27	26
121.1	150	129	128	27	26
121.1	151	129	128	27	26

condition9 The beginning of the test 2) 2hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	163	135	132	27	27
125.0	164	136	136	27	27
125.0	162	136	132	27	27

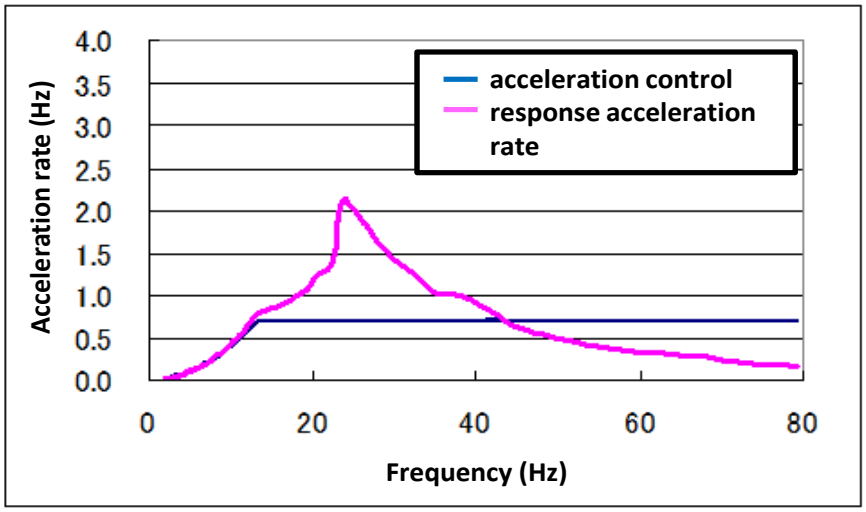


Fig1.12 response acceleration rate after earthquake resistant tests

condition10 Test 3)、around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	163	135	132	27	27
125.0	163	136	132	27	27
125.0	163	135	132	27	27

condition11 Test 3)、around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	163	136	133	27	27
125.0	163	136	133	27	27
125.0	163	136	133	27	27

１．２．３ Z direction（Apparatus original center of the forehead or up and down）vibration

condition0 Before the beginning of the test

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	152	137	129	30	27
125.0	151	137	129	30	27
125.0	152	137	129	30	27

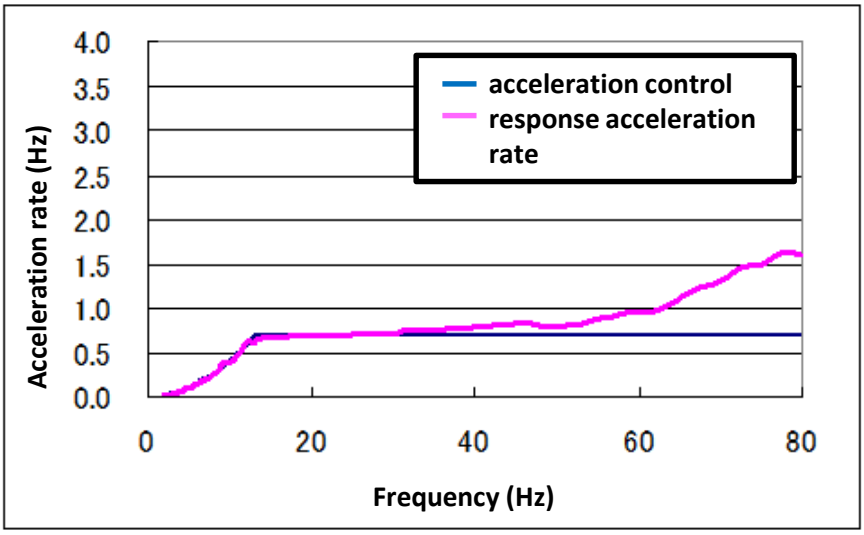


Fig1.13 response acceleration rate before earthquake resistant tests (three test cycles)

condition1 Test cycle1: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	153	143	129	30	27
125.0	153	143	129	30	27
125.0	153	143	129	30	27

condition2 Test cycle1: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	152	144	129	30	27
125.0	153	144	129	30	27
125.0	153	144	129	30	27

condition3 Test cycle2: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
125.0	152	144	129	30	27
125.0	152	144	129	30	27
125.0	152	144	129	30	27

condition4 Test cycle2: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	153	144	129	30	27
121.1	153	144	129	30	27
121.1	153	144	129	30	27

condition5 Test cycle3: around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	161	137	128	29	27
121.1	161	137	128	29	27
121.1	161	137	128	29	27

condition6 Test cycle3: around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	160	139	129	28	27
121.1	160	138	129	28	27
121.1	160	138	129	28	27

condition7 Just after the beginning of the test 2) (70Hz)

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	162	140	128	28	27
121.1	162	140	128	28	27
121.1	162	140	128	28	27

condition8 The beginning of the test 2) 1hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	157	148	128	28	27
121.1	157	147	128	28	27
121.1	157	147	128	28	27

condition9 The beginning of the test 2) 2hour later

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	159	143	127	28	27
121.1	159	143	127	28	27
121.1	159	143	127	28	27

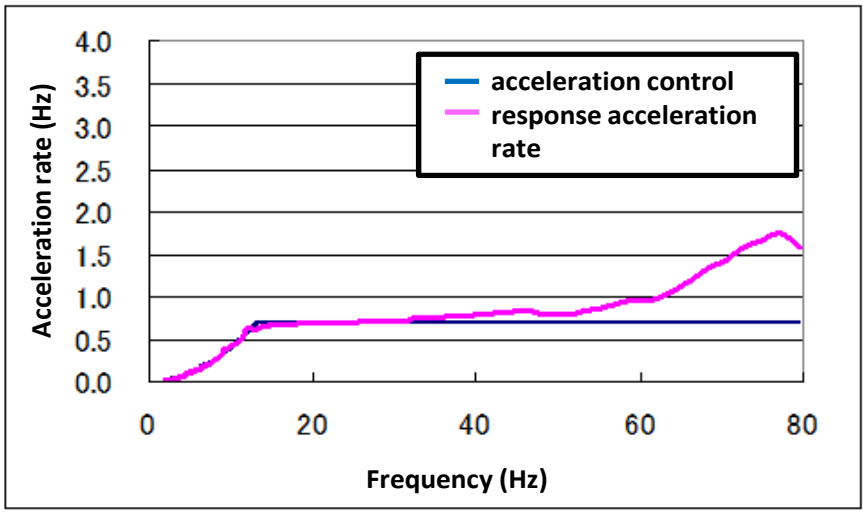


Fig1.14 response acceleration rate after earthquake resistant tests

condition10 Test 3)、around 13Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	162	143	128	28	27
121.1	162	143	128	28	27
121.1	162	143	128	28	27

condition11 Test 3)、around 70Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %
121.1	162	142	129	28	27
121.1	162	142	129	28	27
121.1	162	142	129	28	27

１．３ Geared motor of filter rotation

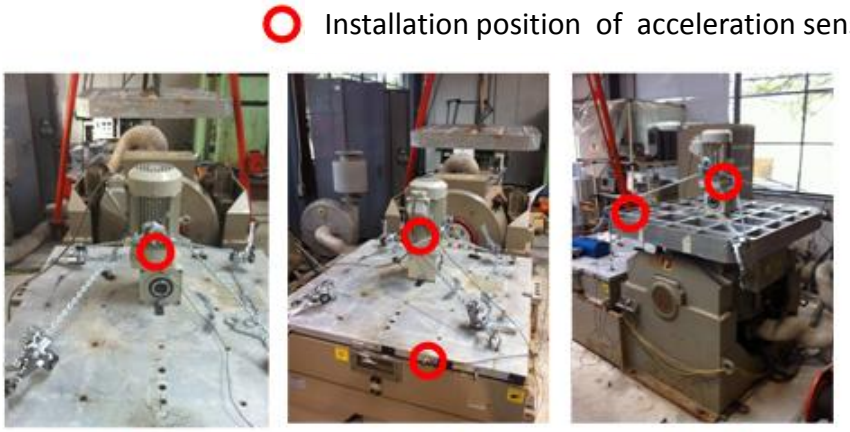


Fig1.15 vibration stage and Installation placementacceleration

１．３．１ X direction（Apparatus original center of the forehead or left and right）vibration

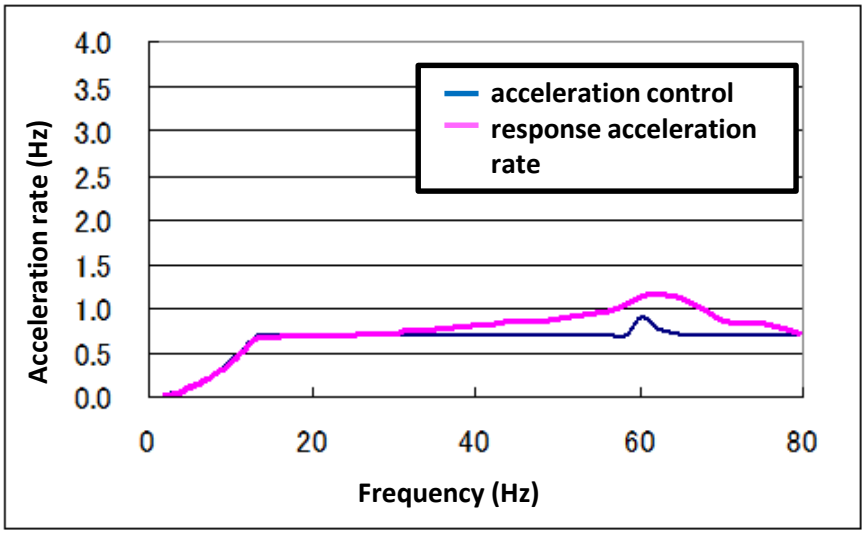


Fig1.16 response acceleration rate before earthquake resistant tests (three test cycles)

test cycle1 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

test cycle2 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

test cycle3 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

confirmation of motor rotation during earthquake resistant test by sight

	Before the beginning of the test	1 hour after beginning of the test	2 hour after beginning of the test
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

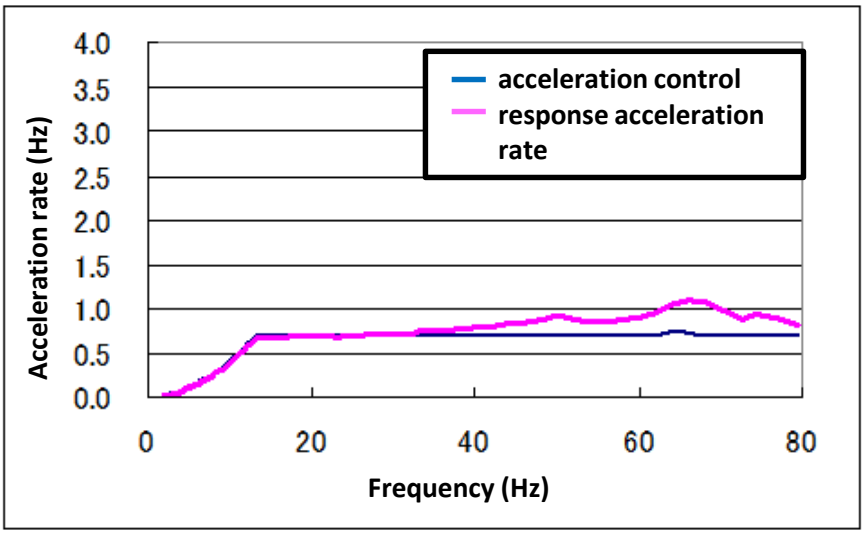


Fig1.17 response acceleration rate before earthquake resistant tests

confirmation of motor rotation after earthquake resistant test by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

１．３．２ Z direction (Apparatus original center of the forehead or front and back) vibration

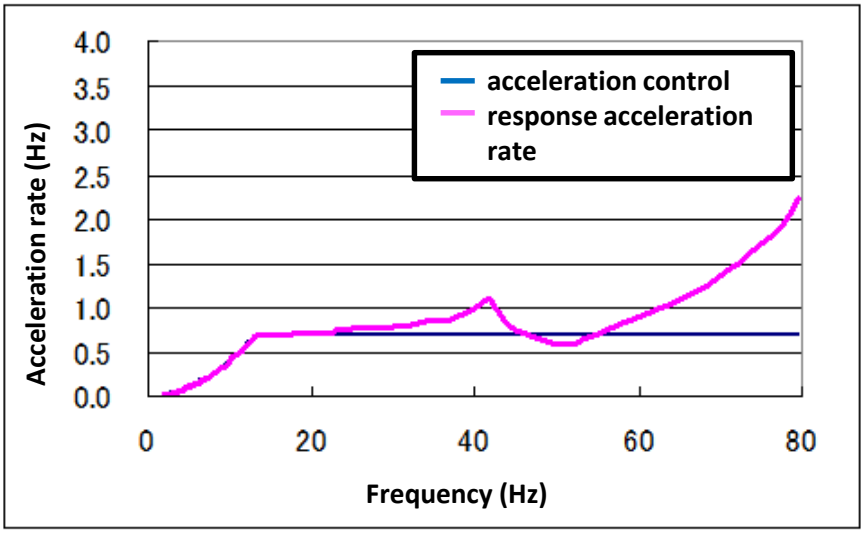


Fig1.18 response accelerationrate before earthquake resistant tests

(three test cycles)

test cycle1 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

test cycle2 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

test cycle3 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

confirmation of motor rotation during earthquake resistant test by sight

	Before the beginning of the test	1 hour after beginning of the test	2 hour after beginning of the test
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

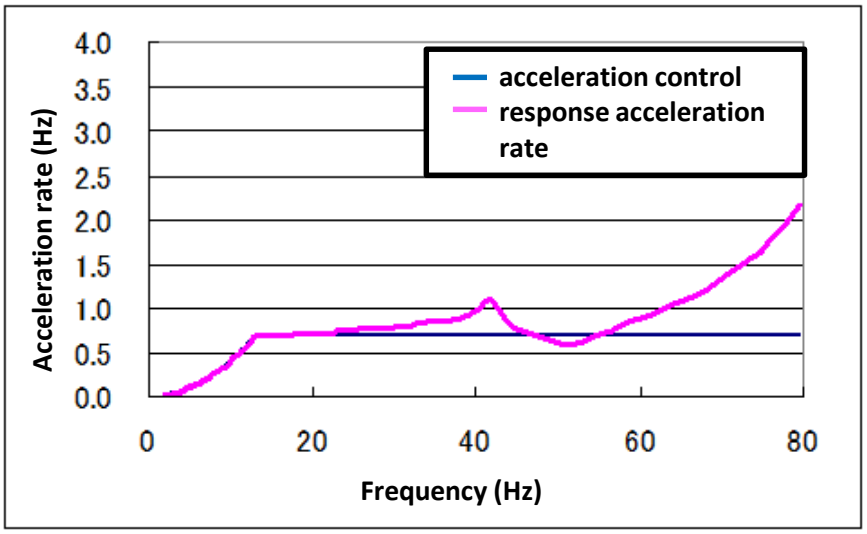


Fig1.19 response acceleration rate after earthquake resistant tests

confirmation of motor rotation after earthquake resistant test by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

１．３．３ Z direction (Apparatus original center of the forehead or front and back) vibration

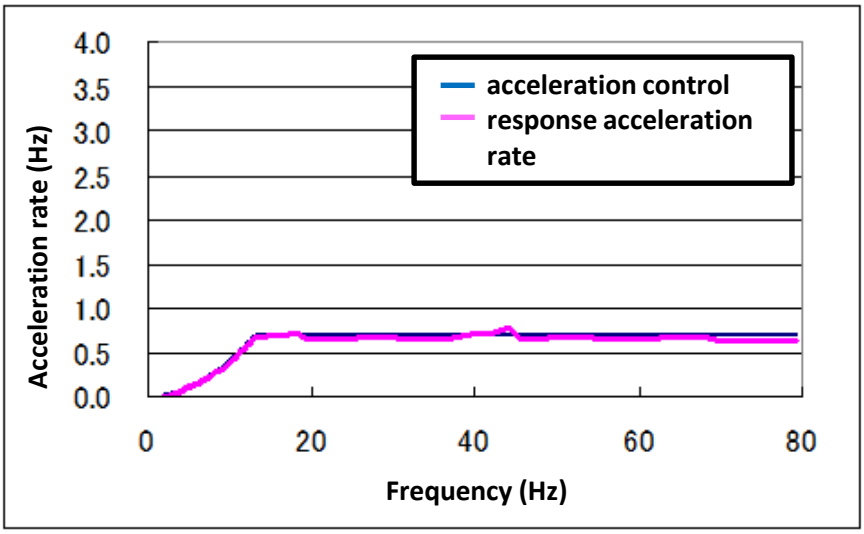


Fig1.20 response acceleration rate before earthquake resistant tests (three test cycles)

test cycle1 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

test cycle2 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

test cycle3 confirmation of motor rotation by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

confirmation of motor rotation during earthquake resistant test by sight

	Before the beginning of the test	1 hour after beginning of the test	2 hour after beginning of the test
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

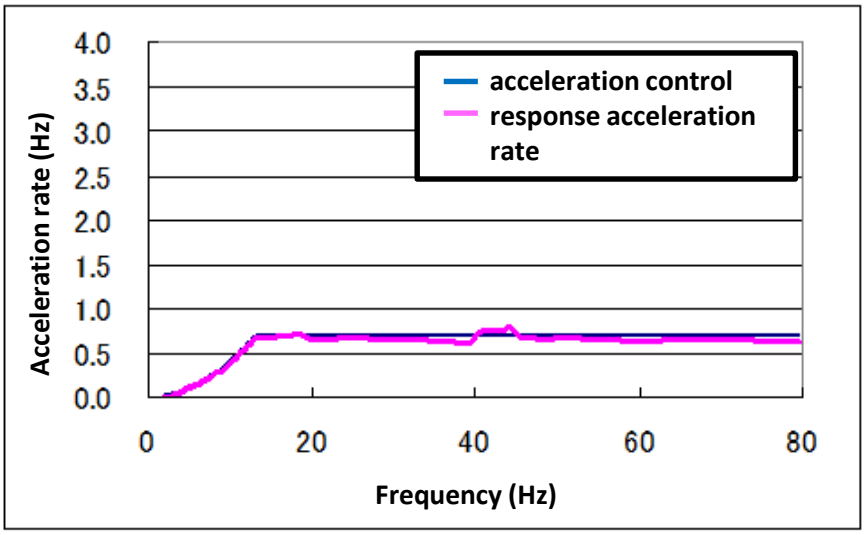


Fig1.21 response acceleration rate after earthquake resistant tests

confirmation of motor rotation after earthquake resistant test by sight

	Before the beginning of the test	around 13 Hz	around 70 Hz
confimation 1	no abnormality	no abnormality	no abnormality
confimation 2	no abnormality	no abnormality	no abnormality
confimation 3	no abnormality	no abnormality	no abnormality

２． Temperature ・Humidity tests(UV chamber, Control panel, motor)

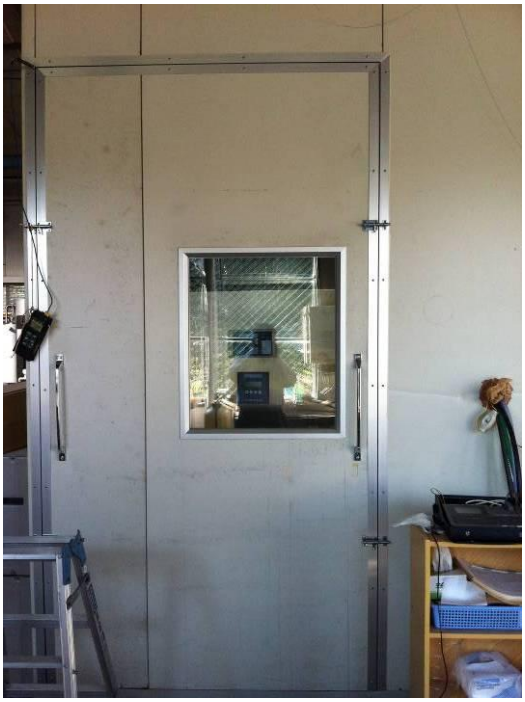


Fig1.22 component set in the large constant temperature tank(inside the window)

２． １ Temperature tests 温度試験

Test method
Maintain the components at 0℃ and 55℃ for at least 2 hours each.
At the end of each test, turn on the power and conduct the operation test under each condition.

Judgement
It is confirmed that there is no abnormality such as breakage, transformation and malfunction.

condition1 temperature 0 ℃
temperature maintain

elapsed time minute	temperature ℃	humidity %
0	1.0	73.8
20	0.4	73.7
40	0.0	75.3
60	0.7	83.7
80	0.7	86.9
100	0.2	84.6
120	0.6	82.8

performance test

temperature minute	humidity %	UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
0.0	81.0	123.7	141	132	128	26	26	no abnormality
0.0	80.8	123.7	142	131	128	26	26	no abnormality
0.0	80.7	123.7	140	131	128	26	26	no abnormality

condition2　　temperature 55 ℃

temperature maintain

elapsed time minute	temperature ℃	humidity %
0	54.0	46.7
15	54.2	50.3
30	54.4	63.1
45	54.6	68.9
60	54.8	70.9
75	54.9	73.2
90	55.2	76.3
105	54.9	72.0
120	54.2	75.4

performance test

temperature minute	humidity %	UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
54.6	70.5	123.7	150	139	126	33	25	no abnormality
54.4	69.7	123.7	149	139	127	33	25	no abnormality
54.5	68.8	123.7	148	138	126	33	25	no abnormality

２．２ Humidity tests

Test method
Turn off the power and leave the component at 55℃and at a relative humidity of 90 % for 2 hours.
Then turn on the and operate them for I hour made the test condition.

Judgement
It is confirmed that there is no abnormality such as breakage, transformation and malfunction.

temperature,humidity maintain

elapsed time minute	temperature ℃	humidity %
0	55.0	90.7
15	54.8	90.5
30	54.7	91.0
45	54.7	91.0
60	54.7	91.3
75	54.8	90.8
90	54.9	90.5
105	54.9	90.1
120	54.9	89.6

condition1 Just after the beginning of the test

temperature minute	humidity %	UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
54.9	89.5	119.9	147	134	125	29	25	no abnormality
54.9	89.6	119.9	147	133	125	29	25	no abnormality
54.9	89.6	119.9	147	134	125	29	25	no abnormality

condition2 30 minutes after the beginning of the test

temperature minute	humidity %	UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
54.8	90.3	119.9	151	137	125	29	25	no abnormality
54.8	90.5	119.9	151	137	125	29	25	no abnormality
54.8	90.4	119.9	150	137	124	29	25	no abnormality

condition3 1 hour after the beginning of the test

temperature minute	humidity %	UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
54.7	91.5	119.9	151	137	124	29	25	no abnormality
54.7	91.4	119.9	150	137	124	29	25	no abnormality
54.7	91.3	119.9	151	137	124	29	25	no abnormality

3. Power supply fluctuation tests(UV chamber, Control panel, motor)

Test method
1) operate the components with a voltage variation of +/- 10 percent together with a simultaneous frequency variation of +/- 5percent.
2) operate the components with a transient voltage of +/- 20 percent together with a simultaneous transient frequency of +/- 10 percent and transient recovery time of 3 seconds.

External view


Main panel

Fig1.23 Power generator of power supply fluctuation tests

Test 1
components must operate properly with a voltage variation of +/- 10 percent together with a simultaneous frequency variation of +/- 5percent..

condition 1 440V, 60Hz :steady state

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	142	130	125	28	26	no abnormality
121.1	144	130	125	28	26	no abnormality
121.1	143	130	125	27	26	no abnormality

condition 2 484V, 63Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	144	130	126	27	26	no abnormality
121.1	147	132	126	27	26	no abnormality
121.1	145	133	126	27	26	no abnormality

condition 3 396V, 57Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	147	134	127	27	26	no abnormality
121.1	147	135	127	27	26	no abnormality
121.1	145	135	127	27	26	no abnormality

Test 2
components must operate properly with a transient voltage of +/- 20 percent together with a simultaneous transient frequency of +/- 10 percent and transient recovery time of 3 seconds.

condition 4　440V, 60Hz :steady state

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	150	136	127	27	26	no abnormality
121.1	147	136	127	27	26	no abnormality
121.1	149	137	127	27	26	no abnormality

condition 5　352V, below 54Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	151	137	127	27	26	no abnormality
121.1	151	138	128	27	26	no abnormality
121.1	150	138	128	27	26	no abnormality

condition 6　528V, over 57Hz

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	156	138	127	27	26	no abnormality
121.1	155	138	127	28	26	no abnormality
121.1	156	138	127	28	26	no abnormality

condition 7　440V, 60Hz :steady state

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	155	138	127	27	26	no abnormality
121.1	153	138	128	27	26	no abnormality
121.1	154	138	128	27	26	no abnormality

Inclination tests (UV chamber, Control panel, motor)

Test method
operate the components under a inclination of 22.5° against normal installation.

Control panel (Left 22.5°)

UV chamber (left 22.5°)

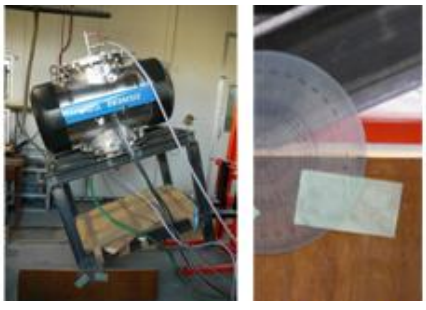
Control panel (back 22.5°)

UV chamber (back 22.5°)

Control panel (front 22.5°)

UV chamber (front 22.5°)

Control panel (right 22.5°)



UV chamber (right 22.5°)

Fig1.24 the situation of inclination tests

Judgement
Operate properly

condition 1　x direction, +22.5°（UV chamber, control panel, motor）

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	153	129	129	30	26	no abnormality
121.1	152	129	130	30	26	no abnormality
121.1	155	128	130	30	26	no abnormality

condition 2　x direction, -22.5°（UV chamber, control panel, motor）

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	154	128	131	30	26	no abnormality
121.1	151	128	130	30	26	no abnormality
121.1	155	128	131	29	26	no abnormality

condition 3　y direction, ＋22.5°（UV chamber, control panel, motor）

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
121.1	153	129	131	29	26	no abnormality
125.0	154	129	132	29	26	no abnormality
125.0	154	130	131	29	26	no abnormality

condition 4　y direction, -22.5°（UV chamber, control panel, motor）

UV irradiance W/m2	S1 W/m2	S2 W/m2	S3 W/m2	water temperature ℃	power supply %	motor rotation -
125.0	156	130	131	29	26	no abnormality
125.0	156	130	132	29	26	no abnormality
125.0	155	130	133	29	26	no abnormality